

Enterprise Productivity Measurement Framework for ERP in Indian Refineries

Himadri Barman

Dibrugarh University, Dibrugarh, Assam, India

Abstract

Across the petroleum refining sector, an effective Enterprise Resource Planning (ERP) system is recognized as an important driver of business success and enterprise productivity. Significant investments have been made in the past on ERP in the refining sector to attain these objectives. Investments continue to be made on these systems for their up-gradation. It has been seen that no systematic study has been carried out to measure enterprise productivity in the refineries due to the implementation of ERP. It is also a fact that measuring enterprise productivity is not easy. This paper looks at ERP user feedback in the refineries of the state of Assam in India to develop an Enterprise Productivity Measurement Framework (EPMF) that may be used in the Indian refineries. The intricacies of the proposed EPMF have been thoroughly explained in this paper by outlining the Key Productivity Indicators (KPIs), Data Sources and Measurement Objectives. A strategy for the implementation of the proposed EPMF is also given.

Keywords: Key Productivity Indicators (KPIs), Measurement Objectives, Measurement Strategy, Productivity Factors, Refinery

JEL Classification: M11

Paper Classification: Research Paper

Introduction

In the last couple of decades, there has been a lot of interest in the term “enterprise”, more specifically on looking at the enterprise as a whole instead of looking at it as fragmented pieces called silos. Productivity may also be given a similar direction wherein the emphasis is on Enterprise Productivity. Enterprise Resource Planning systems by the very nature of their integrating philosophy and their deployment across organizations, large and small are a critical aspect of Enterprise Productivity. The operational definition of Enterprise Productivity in the context of the Measurement Framework as discussed in this paper is taken as “the increase in user satisfaction, process improvement, better management, cost control, knowledge enhancement, collaboration and innovation brought about by adoption of Enterprise Resource Planning (ERP) software in the Indian refineries” (Barman & Bhattacharjee, 2014).

In today’s business enterprises, Information Technology (IT) plays a very critical role in managing and raising productivity. It is through IT that an enterprise harnesses the power of



information which is vital for communication, collaboration and management. This, in turn, drives enterprise productivity. In recent years, more and more enterprises are using ERP in their business processes and integrating their business functions. Research has pointed towards the fact that successful ERP systems can greatly raise enterprise productivity (Sun, 2007). The difficulty is in measuring the enterprise productivity due to ERP. The measures which are ordinarily used to measure productivity are metrics like labour productivity and even multifactor productivity. These metrics are about adding up all the known inputs and outputs and then performing empirical studies and doing the necessary calculations. The process of digitization of business and business processes in the 1980s involving the use of personal computers, computer networks and information systems exponentially aggravated the problem of measuring productivity due to the use of IT. As digitization touched more parts of the enterprise, measuring productivity continued to become more difficult (Baker, 2007).

A single measure for productivity is not feasible in the context of IT. Productivity due to IT is typically assessed in terms of economic efficiency (related to unit costs of key IT services) and support ratios (business or technology volumes in relation to IT services or staffing levels). Economic efficiency is important as there is significant investment due to IT. In addition, IT productivity is often measured in the context of the outcome of using automation to provide operational efficiency. Ratios of operating expenses to IT expenses play a role in gauging IT productivity, but more so in a time series model than at a single point of time. From yet another angle, the productivity of IT is often viewed in the context of the growth rate of key business transactions and volumes or activities versus the change in IT expenses. Overall, it is the pattern of change in all of these dimensions that is critical to an assessment of IT productivity (Rubin, 2012).

According to the ISO International Vocabulary of Metrology (VIM), a Measurement Method may be defined as a generic description of a logical organization of operations used in measurement. An Analysis Model on the other hand is defined as an algorithm or calculation which combines the required measures obtained from the adopted measurement method. The output of the analysis model is used to produce evaluations or estimates relevant to the information needed for decision making.

The ISO (International Organization for Standardization) 15939 has described the purpose of a measurement process. It says that the purpose is to collect, analyze, and report data relating to the products that have been developed and the processes that have been implemented within the organizational unit. The whole idea behind the measurement process is to support effective management of the implemented processes and to demonstrate the quality of the developed products in an objective manner. ISO 15939 defines four sequential activities for the measurement process (Bautista, Abran & April, 2012):

- Establish a policy for the measurement process
- Develop a plan to carry out the measurement process
- Execute the measurement process
- Carry out an evaluation of the measurement process

The Performance Measurement Framework for the Canadian Transport Agency has listed five criteria that should be utilized in determining the most appropriate indicators to measure performance:

1. The Validity of the indicators. This criterion assures that the indicators precisely measure the performance.

2. The Relevance of the indicators. This criterion makes it sure that the selected indicators are relevant to the activity, product or process being measured.
3. The Reliability of the indicators. This criterion is required to see that the indicators are able to consistently measure performance over a period of time.
4. The Simplicity of the indicators. It is essential to see that the indicators are looking at the available information and analyze it in a feasible manner.
5. The Affordability of the indicators. The indicators should collect and analyze the information in an affordable manner.

Performance is different from productivity conceptually but it has to be kept in mind that performance incorporates productivity. Productivity is a very specific concept related to the ratio between output and input while performance is a broader concept that covers both the economic and operational aspects of an enterprise. Performance talks about excellence and includes profitability and productivity among other non-cost factors, such as quality, speed, delivery and flexibility (Pekuri, Haapasalo & Herrala, 2011). The five criteria specified above to determine the most appropriate indicators to measure performance may thus also be used to determine the most appropriate indicators to measure productivity.

Purpose of the Enterprise Productivity Measurement Framework

Assam has four refineries at Bongaigaon, Digboi, Guwahati and Numaligarh of varied capacity ranging from 0.65 Million Metric Tonnes per Annum (MMTPA) at Digboi to 3 MMTPA at Numaligarh. The capacity of Guwahati Refinery is 1.0 MMTPA and that of Bongaigaon Refinery is 2.35 MMTPA. The refineries at Bongaigaon, Digboi and Guwahati are operated by Indian Oil Corporation (IOC) which is India's largest crude oil refining company. The fourth one at Numaligarh is run by the public sector company, Numaligarh Refinery Limited which has Bharat Petroleum Corporation Limited (BCPL) as its largest shareholder. All the refineries have installed ERP in the late 1990s and early 2000s. As per the information obtained in 2014, the ERP package used in all the refineries of Assam is SAP ECC 6.0 or ERP Central Component Version 6.0. The SAP Modules and Components being used are: ABAP (Advanced Business Application Programming), SAP Basis, FICO (Financials and Controlling), HR (Human Resource), MM (Materials Management), PJ (Payroll Journal), PM (Plant Maintenance), PP (Production Planning), PS (Project System), QM (Quality Management) and SD (Sales and Distribution). There were 268 SAP user licences in use at Digboi Refinery, 271 at Guwahati Refinery, 328 at Numaligarh Refinery and 343 at Bongaigaon Refinery, which adds up to a total of 1210 SAP user licences in the refineries of Assam as per data provided by the refineries in early 2014. The total number of licenced users as mentioned does not include the ESS (Employee Self Service) users. ERP users in the refineries of Assam are not too clear either about Enterprise Productivity or the ways of measuring it as revealed by the survey conducted amongst 239 SAP users in the refineries of Assam out of the total of 1210. The productivity study undertaken was in the context of the use of SAP in the refineries of Assam. An important reason for the low awareness on enterprise productivity and the ways of measuring it is because of the fact that a variety of technical issues are intimately built into the definition and measurement of productivity (Li, 2013). Yet measuring enterprise productivity in the Indian refineries due to ERP is important as the results of the measurement may be used for a variety of reasons starting from improving processes, manufacturing of products, application programming, employee activities, and for taking better decisions in enterprise management (Selmeçi, Orosz, Györök & Orosz, 2012).

A Productivity Measurement Framework (PMF) for Enterprise Productivity due to ERP in Indian refineries should be able to identify and quantify “normal productivity”. This identification and quantification should be done in such a way that it serves as a baseline for detecting possible anomalies in the functioning of the ERP that may impact enterprise productivity. A measurement model has to be used for the identification of the base measures specific to enterprise productivity due to ERP and their quantification. An analysis model will then help to determine the relationships that exist among these measures.

Ruivo, Johansson, Oliveira & Neto have identified six productivity factors with respect to ERP (Ruivo, Johansson, Oliveira & Neto, 2013):

- **Compatibility:** It is used to measure the degree of compatibility of the implemented ERP system with existing hardware and other software.
- **Complexity:** It measures the user-friendliness of the ERP system by looking at the intuitiveness of the application, the time taken for users to become proficient with the application; and the comfortable level of the users in using the ERP.
- **Efficiency:** It is used to measure the efficiency of transactions vis-à-vis the ERP system by tracking the comfort level of users in executing common and repetitive tasks, the ability of the user interface in carrying out the tasks smoothly, and the speed and reliability of the system.
- **Best-practices:** It measures the difficulty level for users to set up the ERP system and map workflows based on the requirements of the enterprise, and also the adaptability of the system to changing business needs.
- **Training:** It is used to measure the comfort level of training users to use the ERP system by looking at the time required to train users on using the system, how easy is it for the users to understand the content material on the system like user manuals, and the ability of the users to navigate through the material to apply in carrying out daily tasks using the system.
- **Empowerment:** It measures the degree of collaboration the ERP system enables, the ability to create custom reports based on the user role and requirements, and quick access to real-time information for faster and effective decision making.

The Enterprise Productivity Measurement Framework has to answer a set of questions related to the design; implementation; use and maintenance of the measurement system in a sequential manner keeping in mind the stakeholders, business processes, prevalent culture and infrastructure of the enterprise (Neely et al., 2000).

Design of the Enterprise Productivity Measurement Framework

Enterprise productivity measurement will be used at the enterprise level for benchmarking the enterprise. The enterprise productivity improvement needs precisely defined productivity measurements. The measures should be SMART, i.e., specific, measurable, attainable, relevant and timely (“content - IEEECS”, 2013).

The purpose of enterprise productivity measurement is having a high degree of certainty and control: certainty in understanding what is being done so as to control, influence, and evaluate as to what is being done. There also needs to be an understanding of the relationship between measurement and the tools employed to collect/measure data on enterprise productivity due to ERP (Scacchi, 1995). The refineries of Assam use a state-of-the-art ERP system in SAP. The system is used for managing all the key functions and processes of the refineries. Keeping in mind the Key Productivity Indicators (KPIs) along with the measurement objectives for each KPI and the data

sources required for each KPI, an enterprise productivity measurement framework is proposed as given below. The KPIs have been obtained from the ERP users of the refineries of Assam and have been elaborated in the next paragraphs. As already mentioned, the feedback was collected from 239 SAP users in the four refineries of Assam, viz., Bongaigaon Refinery, Digboi Refinery, Guwahati Refinery and Numaligarh Refinery.

Measurement Objective	Maximize Output	Maximize Share Value	Optimize Inventory	Optimize Quality	Optimize Process	Increase Usage	
Data Sources		External Data			Data Captured by ERP		User Feedback Data
Key Productivity Indicators	GRM	Market Capitalization	MOU Targets	MBN, F&L, Yield	Operating Cost / Unit Production	User Satisfaction	

Figure 1 : Proposed Measurement Framework. (This figure illustrates the proposed Measurement Framework for measuring Enterprise Productivity in Indian refineries).

As is seen, most of the data will be captured by the ERP for the KPIs – GRM, Market Capitalization, MOU Targets, MBN, F&L, Yield and Operating Cost / Unit Production. Additionally, the measurement framework as proposed will rely on external data for the KPIs, Market Capitalization and MOU Targets. For the KPI, User Satisfaction, the data source will be User Feedback Data.

There is a difference between the total value of petroleum products coming out of an oil refinery (output) and the price of the raw material (input), which is crude oil. This is called the Gross Refining Margin (GRM) which is calculated on a per-barrel basis. One barrel of crude oil is roughly equal to 159 litres of crude oil. Crude oil when cracked chemically through various processes in a refinery produces an entire range of products like petrol, diesel, aviation fuel, wax, LPG and furnace oil, each having different uses.

The amount of energy consumed in a refinery per barrel of crude processed per unit energy factor is known as MBTU/BBL/NRGF (MBN). MBTU denotes the total heat value of the fuel and the attributed loss in thousand BTU (British Thermal Units). BBL refers to a barrel of crude oil that is processed. NRGF which is the abbreviated form of Nelson’s Refinery Grading Factor is a composite energy factor of the refinery that is influenced by the actual intake in both primary and secondary processing units as per the refining industry standards. F&L stands for Fuel and Lubricants, the outputs of a refinery.

All CPSEs (Central Public Sector Undertakings) have to sign an MOU (Memorandum of Understanding) with their respective administrative Ministries or Departments of the Government or Holding Companies. In case of Indian Oil Corporation Limited (IOCL), MOU is signed with the Ministry of Petroleum & Natural Gas (MoPNG), Government of India. In case of NRL, the MOU is signed with BPCL, the holding company of NRL. The MOU has a set of Criteria and Targets specified for a particular financial year which are selected by the respective refineries from a set of parameters given by the Department of Public Enterprises (DPE), Ministry of Heavy Industries and Public Enterprises, Government of India. Each of them has different weightages.

For the financial year, 2015 – 16 with respect to IOCL, the evaluation criteria are Static / Financial Parameters (50% weightage), Initiatives for Growth (19% weightage), Project Management and Implementation (10% weightage), Productivity and Internal Processes (7% weightage), Technology, Sector Specific / Enterprise Specific Parameter (6% weightage), Quality and Innovative Practices (4% weightage), Research & Development (3% weightage) and Dynamic / Non-financial Parameters (1% weightage) (2015). In case of NRL, for the financial year 2015 – 16, the evaluation criteria are Static / Financial Parameters (50% weightage), Initiatives for Growth (25% weightage), Project Management and Implementation (10% weightage), Productivity and Internal Processes (8% weightage), Sector Specific / Enterprise Specific Parameter (5% weightage) and Quality and Innovative Practices (2% weightage) (“Numaligarh Refinery Limited is Public Sector oil Company India”, 2015).

The Global Reporting Initiative (GRI) Reporting Framework has designed a generally accepted framework for reporting on an enterprise's economic, environmental, and social performance. It may be used by enterprises of any size, sector, or location. The GRI Reporting Framework has taken into account the practical considerations faced by an assorted range of enterprises – from small enterprises located in a single location to very big enterprises with extensive and geographically dispersed operations. The GRI Reporting Framework contains very general content that may be used by any enterprise as well as sector-specific content that has been decided by different stakeholders around the world related to that sector to be generally applicable for reporting a sector-specific enterprise's sustainability performance.

GRI G3 Guidelines has two parts. Part 1 is called the Reporting Principles and Guidance. It features guidance on how to report by the enterprise. Part 2 is called the Standard Disclosures. It features the Disclosures on Management Approach and Performance Indicators which gives guidance on what should be reported by the enterprise (2011). Numaligarh Refinery comes out with a Sustainable Development Report (SDR) which details its compliance with GRI G3 guidelines. The level of reporting during the period 2013 – 14 and 2012 – 13 adhered to the A+ level as per GRI G3.1 guidelines whereas the report pertaining to 2011 – 12 adhered to B+ level as per GRI G3 guidelines.

Satisfaction with respect to users is driven by more than an attractive and engaging user interface. It must be evaluated on the basis of multiple dimensions vis-à-vis the user. The framework as proposed will assess user satisfaction of ERP along six major dimensions. These have been adopted from a study conducted in 2007 by market research firm, Keystone Strategy.

- **Usability** – It is designed to measure the usability of the system in use. It will include user's perception about the ERP system in terms of how easy it is to use, how much control of the system the user is in, how comfortably the user is able to navigate the user interface of the ERP, and how much the user enjoys using the ERP.
- **Familiarity** – It will measure the effort required on the part of the user to get familiar with the ERP system. It will look at the user's perception of how instinctive the ERP interface is, how quickly the user can learn using the system, how quickly they can acquire proficiency in using the ERP system, and how comfortable they feel using it.
- **Transactional Efficiency** – It is designed to measure efficiency of transactions carried out using the ERP system in terms of the user's perception to easily execute common and repetitive tasks, how speedily the user interface allows the execution of the tasks, and the reliability of the ERP system.
- **Flexibility** – It will measure as to how easily infrequent or unusual tasks in the ERP system

may be executed from the user's perspective, the adaptability of the ERP to meet specific new business needs and processes, and the agility of the ERP in handling problems that arise unexpectedly.

- **Business Insight** – It will measure the ability of the ERP system to carry out easy and comprehensive reporting, access to real-time information as and when required, access to cross-departmental information, and the capability to gauge the impact of business decisions, all from the perspective of the users of the ERP.
- **Collaboration** – It will measure the collaborative impact of the ERP system in terms of helping the users to work and communicate with their colleagues; share and review work with other users; and communicate with the suppliers, partners, and customers of the enterprise to add value to the enterprise.

For the enterprise measurement framework to be effective, a measurement strategy is proposed. The strategy shows the path that has to be followed while carrying out the measurement. The need assessment gives us the measurement framework that has already been specified. It has then to be implemented. The users of the measurement framework have to be trained in using the process of measurement. Its effective use has to be ensured and care taken to reduce the errors of measurement. Ultimately the system of measurement has to be upgraded from the feedback received.

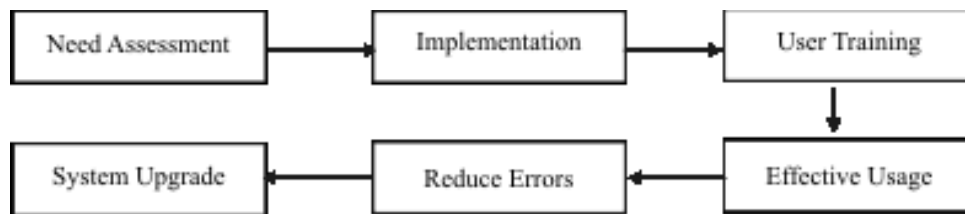


Figure 2: Implementation Strategy (This figure illustrates the strategy for implementation of the proposed Measurement Framework for measuring Enterprise Productivity in Indian refineries).

Conclusion

Productivity is a key indicator in the assessment of the performance of an enterprise. Measurement of enterprise productivity is crucial when significant investments are made with the purpose of increasing enterprise productivity. The effectiveness of ERP in ensuring enterprise productivity in the refineries of India can be understood only if there is a mechanism of measuring the enterprise productivity because of the use of ERP in India's refineries. Unfortunately, no such measurement mechanism exists. Through a literature survey on measurement frameworks and data collected from the SAP users of the refineries of Assam, a measurement framework has been proposed which may be used in any refinery in India as the refineries of Assam operate in more or less the same environment as the refineries in the other parts of India. The intricacies of the proposed enterprise measurement framework have been explained. Also, a strategy for the effective implementation of the enterprise measurement framework has been given.

KPIs are important to see to it that an ERP project is able to give business results on expected lines and that they can be measured. This is the reason why organizations should use KPIs during and after ERP implementation. Measurement frameworks are a way of structuring KPIs around the strategy, goals, and objectives of the enterprise. The key thing about a measurement framework is that it is comprehensible and helps the enterprise to understand the relationship

between the KPIs as also the KPIs themselves. Data is generally not a problem but the real issue is to get hold of the right data for the right measurement. A robust enterprise measurement framework is a key requirement to analyze current enterprise productivity and improve upon it.

With the emergence of cloud-based ERPs and the benefits they provide like the availability of facts and figures in real time, cutting-edge visibility, and improved task automation, cloud-based ERPs are being increasingly preferred (Thangavel & Sudhaman, 2017). It is a matter of time that Indian Public Sector Units (PSUs) including the government owned refineries go for aggressive implementation and use of cloud-based ERPs (2011). As and when that happens, the measurement framework as proposed has to incorporate some changes to reflect the synergies that cloud-based ERP can bring in terms of data handling and processing.

The study can be used as a basis to develop similar measure frameworks in other countries in the refining sector and also in other sectors.

References

- Baker, E. H. (2007). IT Productivity: Measuring the Immeasurable. Retrieved from <http://www.cioinsight.com/c/a/Trends/IT-Productivity-Measuring-the-Immeasurable>
- Barman, H., & Bhattacharjee, D. (2014). Understanding Enterprise Productivity – An Information Technology Perspective. *DAVCC's Advance Management Research: An International Journal*, 2(3), 11 - 20.
- Bautista, L., Abran, A., & April, A. (2012). Design of a Performance Measurement Framework for Cloud Computing. *Journal of Software Engineering and Applications*, 5, 69 - 75.
- Computer Science Curricula (2013) Retrieved from <http://www.computer.org/web/software-technologies/content?g=5954967&type=blogpost&urlTitle=measuring-productivity>
- IEEE Computer Society India Council, Quarterly E-Newsletter, 1st October 2012. Retrieved from https://www.pwc.in/assets/pdfs/publications-2011/cii_it_4.pdf content - IEEECS.
- Li, J. (2013). *Introduction to Productivity Measurement Framework*. Canberra: Department of Industry, Innovation, Science, Research and Tertiary Education.
- Memorandum of Understanding between Indian Oil Corporation Limited and Government of India, Ministry of Petroleum and Natural Gas for 2015-2016. Retrieved from https://www.iocl.com/download/Govt_MoU_15-16.pdf
- Neely, A., Mills, J., Platts, K., Richards, H., Gregory, M., Bourne, M., & Kennerley, M. (2000). Performance measurement system design: developing and testing a process-based approach. *International Journal of Operations & Production Management*, 20(10), 1119-1145. doi: 10.1108/01443570010343708
- Numaligarh Refinery Limited is Public Sector oil Company India. (2015). Retrieved from http://www.nrl.co.in/mou/2015_16/MoU-2015-16.pdf
- Pekuri, A., Haapasalo, H., & Herrala, M. (2011). Productivity and Performance Management – Managerial Practices in the Construction Industry. *International Journal of Performance Measurement*, 1, 39 - 58. [resourcelibrary/G3-Guidelines-Incl-Technical-Protocol.pdf](http://www.researchgate.net/publication/266141431_Productivity_and_Performance_Management_-_Managerial_Practices_in_the_Construction_Industry)
- Rubin, H. (2012). *How to Assess Your Firm's IT Productivity*. Retrieved from <http://www.wallstreetandtech.com/infrastructure/how-to-assess-your-firms-it-productivity/a/d-id/1265562>
- Ruivo, P., Johansson, B., Oliveira, T., & Neto, M. (2013). Commercial ERP Systems and User Productivity: A Study Across European SMEs. *Procedia Technology*, 9, 84-93. doi: 10.1016/j.procty.2013.12.009



- Scacchi, W. (1995). Understanding Software Productivity. In W. Hurley, *Software Engineering and Knowledge Engineering: Trends for the Next Decade* (pp. 37 - 70). Singapore: World Scientific Publishing Co Pvt Ltd.
- Selmeci, A., Orosz, I., Györök, G., & Orosz, t. (2012). Key Performance Indicators used in ERP performance measurement applications. In *2012 IEEE 10th Jubilee International Symposium on Intelligent Systems and Informatics* (pp. 43 - 48). Subotica, Serbia: Institute of Electrical and Electronics Engineers (IEEE).
- Sun, B. (2007). A Study on Tacit Knowledge Sharing in ERP Enterprises. In L. Xu, A. Tjoa & S. Chaudhry, *Research and Practical Issues of Enterprise Information Systems II* (pp. 763 - 770). Boston, MA: Springer.
- Sustainability Reporting Guidelines (2011). Retrieved from <https://www.globalreporting.org/>
- Thangavel, C., & Sudhaman, P. (2017). An Exploratory Case Study on Cloud ERP Implementation. *International Journal of Information And Communication Technology*, 10(2), 148. doi: 10.1504/ijict.2017.10002126
-

Author's Profile

Himadri Barman is an Assistant Professor of Systems Management at Centre for Management Studies, Dibrugarh University, Dibrugarh, Assam, India. His qualifications include M.Sc. in Mathematics, M.Tech in Information Technology, & Ph.D in Business Administration. He has a teaching experience of over 14 years at Dibrugarh University with research interests in information systems and productivity. He takes interests in conservation of wildlife, heritage, etc. and works in these areas during his spare time.
